The Czech Approach in the Development of a NATO Interoperable Ground Forces Tactical Command and Control System

Milan Šnajder, Jaroslav Horák
Military Technical Institute of Electronics
Pod Vodovodem 2, Prague,
Czech Republic
msnajder@vtue.cz, jhorak@vtue.cz

Václav Jindra, Ladislav Nesrsta
DelINFO, s.r.o.
Chodská 15, Brno
Czech Republic
vjindra@delinfo.cz, lnesrsta@delinfo.cz

Abstract - This paper describes systems engineering and system architecture design and development of the Ground Forces Tactical Command and Control System (GF-TCCS) of the Army of the Czech Republic. The design objective of the GF-TCCS is to provide automation support to commanders and their staff, based on the mission and phase of operations. The objective system will use a high proportion of commercial-off-the-shelf networking software, GIS products and government-off-the-shelf equipment, including military mobile radios and switches, tactical platforms (e.g. trucks, containers, armored personal carriers).

Introduction

At present the Army of the Czech Republic (ACR) doesn't have an integrated, automated ground forces tactical command and control system. Commanders and staffs generally perform their mission using a manual system, augmented by some commercially available hardware and software systems. Some automation and communications systems operated in mutually isolated manner do not provide the mobility, functional flexibility, security, survivability, and interoperability required for ACR's GF-TCCS.
At the and of 1997, the Military Technical Institute of Electronic (MTIE), Prague was selected to provide a system integrator's mission for the GF-TCCS of the ACR programme. For technical advice, the ACR called on the U.S. Army's systems engineers for digitization, the MITRE Corporation.

Objective

The MTIE objective, in partnering with MITRE, was to jump-start common effort at developing a tactical command and control (C^2) system for Czech ground forces - by bringing to bear on the ACR's requirements MITRE's expertise in C^2 and MITRE's years of experiences in engineering the U.S. Army's tactical C^2 systems.

Operational requirements

GF-TCCS has to provide seamless connectivity from the lower tactical (squad/mobile plaform, platoon) level to the Operational Commands (Ground Forces Command and Territorial Forces Command). GF-TCCS will be used regularly within garrison, during deployment, and in the field to maintain the soldier's proficiency at the level required to respond to the broad range of potential missions.

GF-TCCS vertically and horizontally integrates information from the squad/mobile plaform to operational commands level. This requires GF-TCCS to fully comply with the seamless data architecture described in the Staff Information Sytem (SIS) ACR concept.

The GF-TCCS operational capabilities will allow the commander and staff to:

- Collect, process and organize large amount of battle information.
- Combine information from multiple sources to create more complete and useful information.
- Process information to analyze trends, detect unusual activities, or predict a future situation.
- Develop courses of action based on situational factors.

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- Exchange information efficiently among and within command posts on the battlefield.
- Present information as graphic displays and textual summaries.

Fundamental to the GF-TCCS operational concept and relevant ***common tactical picture*** is a single entry, near-real-time information, and automated interoperability between each battlefield information system. The GF-TCCS must provide sufficient interoperability that data entered at any node in the architecture is distributed to all other nodes requiring that data without the need to copy or re-enter data. The elapsed time from initial data entry to receipt at other nodes in the architecture shall be consistent with the needs of the operational mission being supported by the data.

System architecture

The GF-TCCS is the integration of five plus one plus three subsystems: five plus one battlefield functional area command and control systems plus three supporting tactical communications and management systems commonly exploited by all six C^2 systems.

Five plus one battlefield functional area C^2 systems provides situational information and decision support to commanders and staffs in the execution of the operational/tactical battle at operational echelon (operational group) and below. Within this integration of systems, the force level database first takes form at the battalion (or battalion task force) to meet the tactical commanders' requirements for common battlefield picture and situational awareness. The GF-TCCS command and control subsystems are heavily oriented toward combat operations.

The five plus one GF-TCCS command and control subsystems are linked by Tactical Area Communications System and by the Combat Net Radio System. Combat forces, weapon systems and battlefield automated systems will be supported by the Integrated Management and Control System that will provide managing of the tactical communications.

GF-TCCS will be linked directly to the SIS ACR, providing the framework for seamless connectivity from the battalion to the General Staff echelons. Objectively, its five tactical C2 subsystems will merge into a single, coherent, interoperable system binding the combined arms battlefield operating systems together within a unifying open system environment (OSE).

The five plus one plus three GF-TCCS's subsystems as shown in Figure 1.

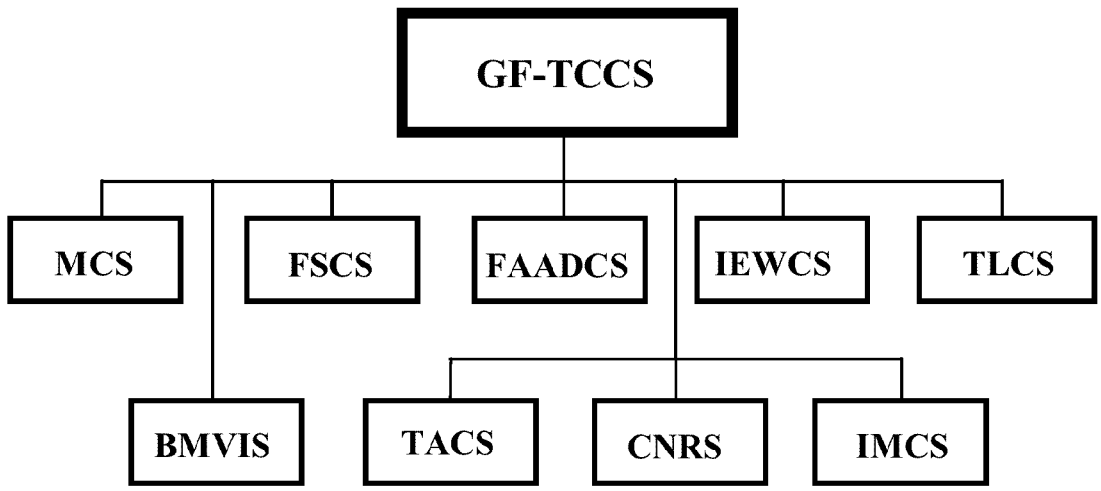

Figure 1: Subsystems of the GF-TCCS

MCS -Maneuver Control System
FSCS -Fire Support Control System
FAADCS -Forward Area Air Defence Control System
IEWCS -Intelligence and Electronic Warfare Control System
TLCS -Tactical Logistics Control System

BMVIS - Battle Management Vehicular Information System

TACS -Tactical Area Communications System
CNRS - Combat Net Radio System
IMCS - Integrated Management and Control System

4		***Common/Unique Applications***	Maneuver control Fire support planning Forward area air defence control Intelligence and EW control Logistics support planning		Engineer support planning Chemical support planning Medical support planning Other special tasks
3	O S E	***Common Support Software Modules***	Office automation (MS Office) Database management/ administration File management Message handling Multimedia support CP's LAN administration Security management Alert and warning services	Simulations Friendly situation Enemy Situation Operational plan, operational order Terrain and weather effects evaluation resources evaluation Supply/equipment status	Convoy planning and control Other common tasks (prognosing of losses, resources completing, combat readiness recovery etc.) Human (soldier)
2		***Open Architecture Software***	Operating system Graphical User Interface Database Management Other COTS system software products		
1		***Common Hardware Suite***	Computers (servers, desktop and notebook PCs, handheld machines) Additional functional hardware modules Peripheral equipment		

Figure 2: Layered GF-TCCS Architecture

The common and unique applications (not part of OSE) will be products embodying specific functions such as movement control, terrain evaluation, operation plan/operation order, etc. The requirements are derived from the various subsystem operational programs. These products will be developed through a rapid prototyping developmental strategy which envisions an incremental, iterative build process, involving close coordination among the user and combat and system developers.

GF-TCCS will use, via communication protocols in the OSE, prepared new ACR's Tactical Area Communications System and Combat Net Radio System. It shall also be able to use strategic(static) MoD/ACR's Common User Communications Network/Army Data Network (CUCN/ADN).

Example of the architectural approach of the MCS

Maneuver Control System (MCS), as a core tactical forces information system, provides commanders and staffs with the capability to collect, coordinate, and act on near-real-time battlefield information. This allows the commander easy access to information, access to display current situation reports, that assess enemy strength, weakesses, movement, and the status of friendly forces. The MCS also aids the

battle staff in rapidly disseminating the commander's orders.

Through the MCS, the commander transmits critical battlefield information, courses of action, schemes of maneuver, warning orders, operation orders, priorities, intelligence requests, and air operations requests. The MCS helps the commander maximize combat power at the appropriate time and place, respond to threats, and anticipate a developing situation.

From battalion through operational commands (or their operational groups), the rapid exchange of information through the MCS gives all command posts the same picture of battlefield. This, along with the capability to query both local and remote databases, helps commanders to synchronize the battle. Commanders at these echelons can make decisions supporting mesh with the decisions and capabilities of other commanders.

Commanders of the tactical forces will use the combat support elements as force multipliers to enhance the combat power of his maneuver units. Digitally equipped combat support elements will use enhanced decision aids and increased situational awareness provided by digital MCS means. Table overview of the MCS major applications:

Application	Functions
Unit Task Organization (UTO)	UTO forms for: UTOs, UTO management, new UTO and copy UTO
Reports	Generate different reports of unit readiness
Electronic Maps and Overlays	Displays maps and associated overlays
Formatted Messages	Creates, edits, and transmits standardized formatted messages
Operation Orders	Creates, edits, transmits and authenticates operation orders (OPORDs) and operation plans (OPLANs)
Synchronization Matrix	Graphic display of unit missions as they relate in time. Can be used to develop Courses of Action (COA).
Command and Control (C2) Products	The file manager functions provide interfaces for the C2 product windows, for example: InBox messages, unread reports, archives files, etc.

Battle Management Vehicular Information System (BMVIS) is a core battalion/brigade and below information system and a key element in the effort to digitize the battlefield.
As organizational/technical arrangement of GF-TCCS computer/communications (CNRS) components at lowest levels inside battle mobile platforms is intended to provide automated capabilities providing time, form and place utility to critical combat information.

The BMVIS will provide the user to access all information collected by sensors in and around his combat vehicle by integrating the information into a single source. Data such as vehicle position, targeting data, chemical contaminants and range to targets will be integrated into the BMVIS situation map and reports which are provided to the commander/user through the interactive display and are transmitted via radio (CNRS) data transmission to all or selected BMVIS in the battalion task force. At the later stages sensors can report on-board logistics (such as fuel, ammunition).

The BMVIS will be a typically MCS-type C2 componets arrangement and will have automated/ programmable interfaces with the co-operating systems of the battlefield functional areas. The BMVIS will also interface with the some NATO

armies automated vehicular C2 systems such as US Army FBCB2/IVIS and FRG IFIS.

Evolutionary systems development and rapid prototyping

The GF TCCS was specified as system of systems (subsystems). Is almost impossible from different view of point to develop all systems together in one time. We took experiences of world's advanced development organizations and we accomodate in GF-TCCS project an evolutionary systems development approach.

This development methodology is based on two main fundamentals:

1. **Incremental development.** Both whole complex and each subsystem is (and will be) developed in a sequence of increments. From the first increment, each of them is fully operable and fully integrated with all preceding increments
2. **Rapid prototyping**. Every planned element and prepared systems is prepared like a prototype and consecutively tested in development labs, in special testbed and in the field as well.

For all teams, that will participate in development process was defined one mandatory methodological standard. The unique methodological basis for GF TCCS is RUP – Rational Unified Process (by Rational Rose). Rational Rose modeling tools are close linked with this methodology and are fully acceptable, because of object orientated system architecture.

Rapid prototyping together with experimentation provides an effective tools for resolving issues, experimental data collection and reducing risk early, and the determining the adequacy of requirements, design, and new GF-TCCS's system capabilities before committing major resources.

The attributes of the proposed approach to evolutionary GF-TCCS development include:

- use of software development environments/tools for rapid prototyping of functionality
- object-oriented design that allow rapid integration of COTS software
- NATO OSE software standards and profiles practices
- documentation appropriate for expansion into formal specifications and
- continuous interaction and feedback from the military end-users

GF- TCCS actual structure

In the year 1999, there were developed starting prototypes of two first subsystems - MCS and BMVIS. MCS is prepared as a base environment for all other subsystem, is oriented to higher tactical and operational-tactical echelons (battalion, brigade, ...). BMVIS is more linked with lower tactical echelons (company, platoon, ...), but some common elements will be used in mobile platforms of higher echelons as well. In the detail analysis phase of MCS and BMVIS, **four main application elements** were specified – TAGIS, ELMET, OTS and FBD.

TAGIS – Tactical Geographical Information System

TAGIS is a proprietary solution of the integrated, geographic and information system designed for the operational and tactical use. It enables the all-round use of the drawing and editing possibilities over the electronic map, which is based on standard graphic data formats (JPEG, VMAP, DTED, CADRG, common used ESRI formats). It is developed especially for the work in the military environment and for the military users (Fig. 3). TAGIS was designed like a multi-purpose system, which can be used both separately and in the computer network operation. It is working over the common database of TCCS objects. It is one of the main supporting means of most of the software applications included into TCCS. It can be also used for supporting the other software applications that respect the defined data interfaces.
In addition to the standard properties of the commercial GIS (graphic information system) TAGIS enables above all:

- The full-value entry of the operational and tactical situations into map with the use of all objects included into these situations in accordance with the standards of the Czech Army and NATO
- The work with the operational and tactical marks and objects according to NATO/APP-6 standards. Creating and editing the new

operational and tactical marks including their text description.

- Interconnecting the plotting of the operational and tactical situation with the database of the forces and means of the friendly troops and the hostile troops. This feature enables to fully support most of the operational and tactical solutions (hereinafter referred to as OTS).

- interconnecting the plotting of the operational and tactical situation and the database of the forces and means with the combat documents.

- The work with the raster and vector data at respecting most of the normally used data interfaces - the raster map basis, the digital model of the terrain and the relief of the terrain, the electronic products of the terrain analysis, the digitized aerial pictures etc.

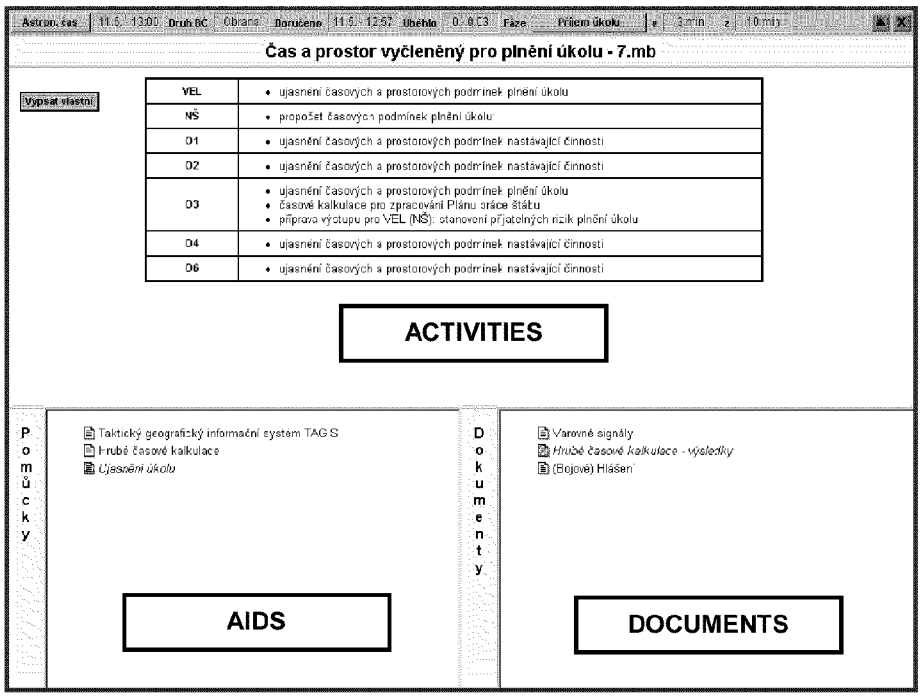

Figure 3

ELMET – Electronic Methodology of Decision Making Process

ELMET is an author's solution of the applied software system which is designed for the control and co-ordination of the all-round support of the decision making process of the commander and the staff from the side of the operational and tactical system (hereinafter referred to as OTS) in the process of planning and conducting the combat activities and as well during performing "out of combat" activities. Actual solution stage covers all main sorts of DMP - Deliberate Decision-Making, Combat Decision-Making, Quick Decision-Making.

ELMET works in the environment of the local computer network of the staff. It is designed as a multi-purpose system and by having been loaded with the appropriate data it can be used not only by the ground forces of the Czech Army but also by the staffs of the Czech Air Force, the Territory Defense Force, the Logistics Headquarters and by the management authorities of the civil institutions dealing with the crisis management.
It is fully compatible with the other software applications of OTS above all with TAGIS application and it is closely co-operating with them. When respecting the defined data interfaces it can co-operate with the other software applications in addition to OTS.

Main properties of ELMET:

- ELMET is a GroupWare solution for the entire local network of the staff. The synchronization of the work at the working places under ELMET is carried out at the time when the chief of staff is formulating the task for the staff.
- Each phase of ELMET has the navigation screens with the standard structure and specific contents defined for the specific staff officer. The navigation screen contains three basic fields (Fig. 4):
  - Field of activities – it defines the standard activities for the individual officers of the staff
  - Field of aids – it contains the software applications to support the standard activities listed in the field of activities. The user can directly activate these applications by using the buttons
  - Field of documents – it contains the list of the formalized documents available with the user during the standard operations defined in the field of activities. The documents can be activated in the same manner as the aids.
- The authorized officer may distribute, in case of need, the various kinds of signals in the staff network by means of ELMET. These signals are always displayed above the active software applications and the precise evidence of their sending out and confirmation is maintained.

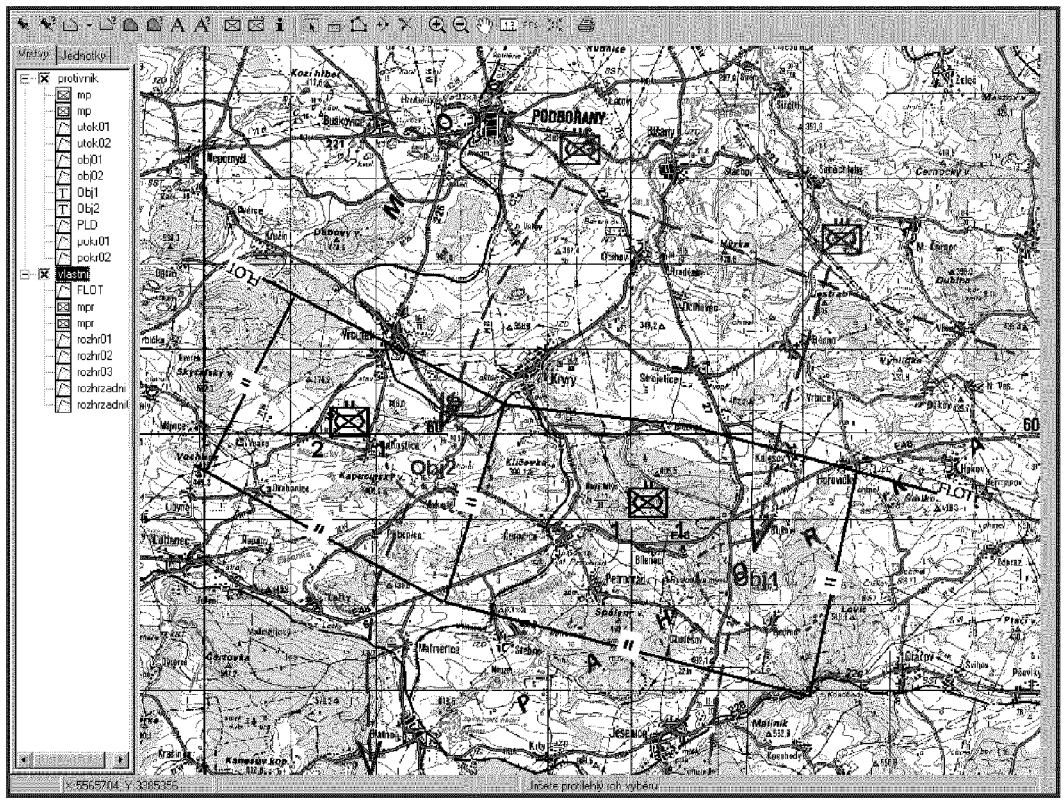

Figure 4

OTS – Operational-Tactical Solutions

This group of applications supports all commanders and staff officer tasks. Total amount of defined OTS has dozens of items. In actual solution stage OTS has about 10 specific applications for supporting typical commander and staff activities:

- Rough Time calculations
- Ratio of power
- Transport calculation
- Electronic methodology of the Topographic data (electronic maps) demand
- Optimum variant selection
- Chemical situation assessment (Fig. 5)

- Protection buildings calculation
- Prediction of a radio-relay communication
- Warning Order (WARNO) preparation
- Situation report (OWNSITREP)
- Distribution of Warning signals
- Management of the tactical database
- Management of applications and users

All of these applications are working over common tactical database and most of them are using TAGIS like a ground for data entry and output. All applications can be lunched from ELMET environment, some of them (non grouping applications) could be run like stand-alone applications.

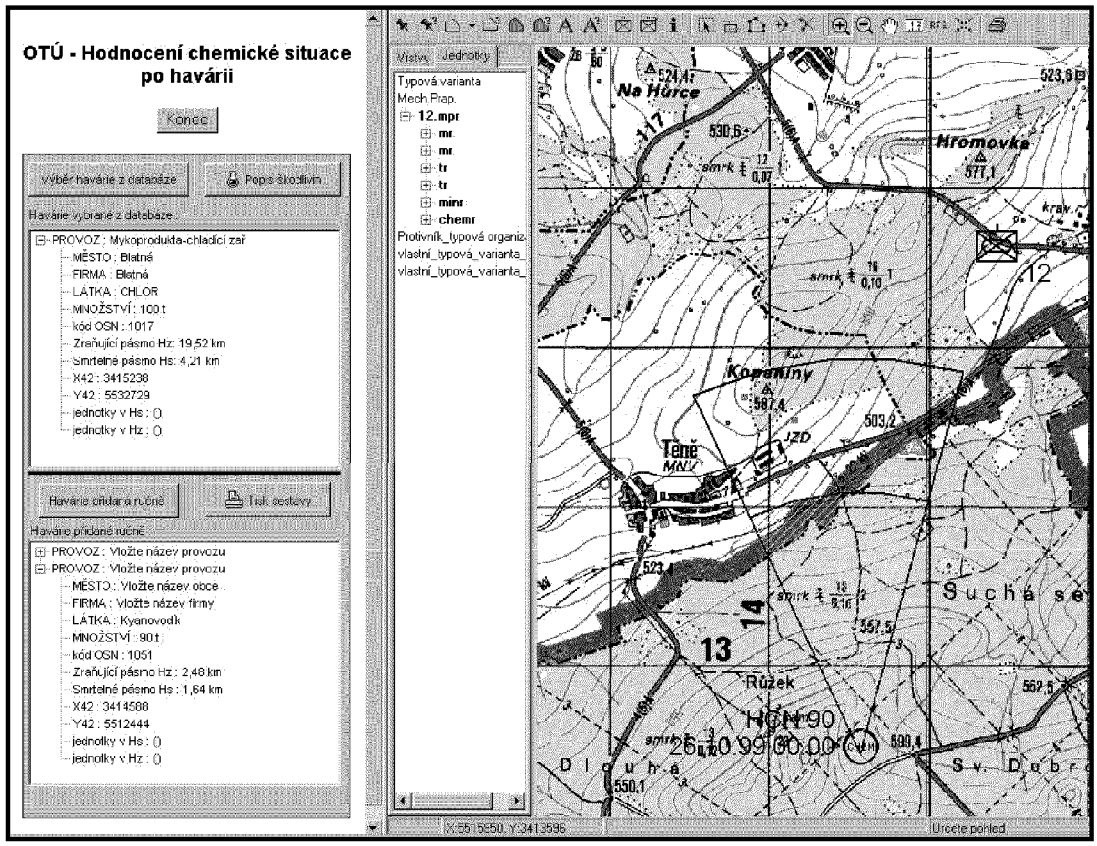

Figure 5

FBD – Formalized Battle Documentation

The application is designed for the group processing of the formalized combat documents. It is a base of the formalized messaging according to STANAG 2014, STANAG 2434 (APP-9), STANAG 5500 (Formets-AdatP3). The structure of the formalized documents being created ensures the operational interoperability of the combat documents according to STANAG 2014. The formalized document can be prepared in the Czech and English language. It ensures the operational interoperability with NATO with respect to the fact that it has the formalized structure (Fig. 6). The full procedure interoperability with NATO in accordance with the AdatP3 standard will be ensured after completing the coding tables of message items.

The application has the following basic features:

- It enables the distributed processing of the documents by the authorized officers of the staff
- It has the direct data relationship to ELMET.
- It receives the data from the centralized database of TCCS.
- It is using the HTML technology, but it complies with the requirements of the standard XML.

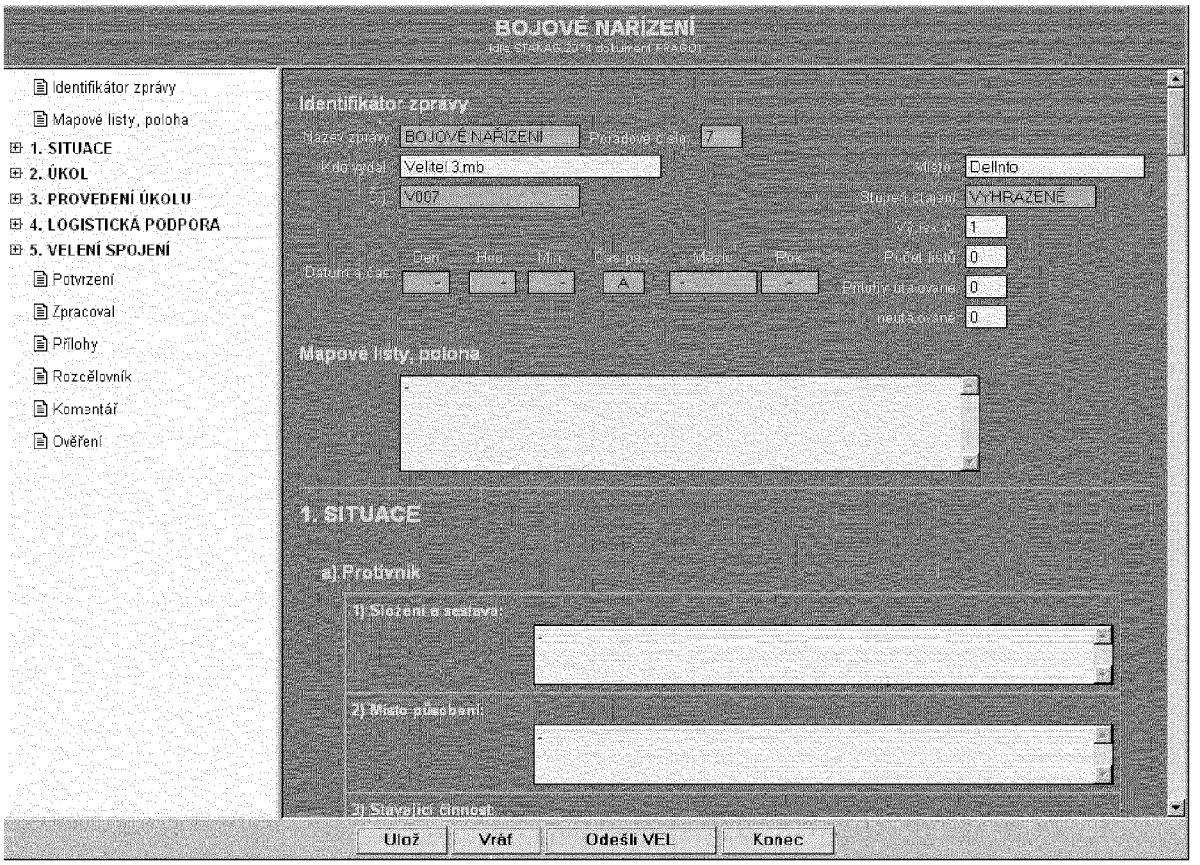

Figure 6

Conclusion

A NATO - interoperable, tactical C2 systems is achievable, in the near term, using off-the-shelf software and hardware. The architecture of the systems will be net-based and state-of-the-art.

GF-TCCS will be the keystone of a future digitized battlefield, providing the commander an integrated digital information network that supports warfighting system and ensures command and control decision cycle strength.

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